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“INTEGRAL legacy: cosmic gamma-ray line results”

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Gamma-ray lines from cosmic sources arise from radioactive decay of unstable isotopes co-produced by nucleosynthesis, from energetic collisions among atomic nuclei which may excite nuclei above their ground level, and from interstellar annihilation of positrons ejected from a variety of candidate sources. Such gamma-ray lines are being measured with ESA's INTEGRAL space mission since its launch in 2002, and complement the earlier survey of NASA's Compton Gamma-Ray Observatory with precision spectroscopy. The current NuSTAR mission now adds observations at the low-energy end for ^{44}Ti decay with an imaging X-ray telescope. The nuclei seen in their characteristic gamma-rays are mainly ^{56}Ni , ^{57}Ni , ^{44}Ti , ^{26}Al , and ^{60}Fe , each from their characteristic sources; also positron annihilation has been measured and mapped throughout the Galaxy both in the 511 keV line and positronium continuum. The ^{26}Al isotope from hydrogen burning has 1 My decay time and has now become a tool to study the \sim My history of specific massive-star groups and associations in nearby regions throughout our Galaxy. ^{60}Fe is co-produced by the sources of ^{26}Al , and its intensity reflects s process neutron capture conditions within the complex shell structure of massive stars. Both those isotopes also have been inferred to have existed in the early solar system, and, moreover, ^{60}Fe has been found in ocean crust samples. Those radio-isotopes are telling a nucleosynthesis story on scales of the Galaxy as well as in specific times where we have the opportunity of measurements.

^{56}Ni and ^{44}Ti gamma-ray lines have been used to constrain supernova explosion mechanisms: For the type Ia supernova SN2014J the surprising gamma-ray line signature points to a non-spherical explosion, from ^{56}Co decay lines, following a primary ignition of the white dwarf surface region, revealed by early ^{56}Ni decay lines. Cas A and SN1987A are the two supernovae seen in ^{44}Ti gamma-ray lines, and the radioactivity gamma rays provide independent clues on how core-collapse and explosion might have happened.

Positron annihilation gamma rays show emission throughout the Galaxy, but the central bulge region seems surprisingly bright. The positron sources are under debate and a variety of candidates exist, from supernovae through pulsars to accreting binaries, and even dark matter may contribute. Recent flaring of an accreting black hole binary was strong enough to reveal a positron annihilation signal, thus seems also a likely candidate source class.

In this talk we will discuss the interplay of such cosmic observations with astrophysical models and nuclear reaction data, in the field of nuclear astrophysics.